Constructing Learning

Using Technology to Support Teaching for Understanding

By Thomas M. Sherman and Barbara L. Kurshan

Subject: Pedagogy, metacognition

Standards: *NETS•S* 3; *NETS•T* II; *NETS•A* II (http://www.iste.org/standards/)

A frequent criticism of technology applications in classrooms is that they are little more than extraneous bells and whistles pointlessly tacked onto routine instruction. The flash and splash of a PowerPoint presentation may look good, but many question the value added to student learning. This leads to the question, how can technologies genuinely contribute to enhanced learning? We need to show explicitly how a constructivist perspective can be helpful in planning and delivering instruction and how technologies can significantly support effective and theoretically sound teaching.

We discussed contructivism in depth in our article last month (December–January). Briefly, constructivism is based on the conception that we learn by relating new experiences to our prior knowledge; we construct new understandings based on what we already know. This theory has emerged from research across a broad range of disciplines, but the challenge has been to understand how to promote deeper, more substantive learning. Three principles capture the essence of the challenge. Understanding is:

- the product of actively relating new and prior experiences
- a function of learning facts and core principles of a discipline
- a consequence of using and managing intellectual abilities well

Interested students challenge their existing knowledge and are more likely to develop conceptual frameworks that integrate prior knowledge and new information into understanding.

As educators, our challenge is to identify, invent, adopt, and use classroom practices that are consistent with these principles. However, this is no easy quest. For example, one common concern relates to the central role of individual prior knowledge. How can we measure and tailor instruction to each individual's unique experiences? Our response is to identify key characteristics of effective teaching consistent with constructivist theory. Then, for each characteristic we identify ways you can use technology to make these characteristics regular features of your classroom.

Consistency between theoretical conceptions of learning and teaching practice has been shown to support effective applications of technologies to increase achievement. We explore eight teaching characteristics that are consistent with constructivist principles:

- Learner centered
- Interesting
- Real life
- Social
- Active
- Time
- Feedback
- Supportive

Learner Centered

Learner-centered classrooms focus instruction on the intellectual strategies, experiences, culture, and knowledge that students bring into classrooms. The instruction you create uses these experiences as learning paths for students to follow as they examine and transform the new ideas into their own understanding. You can use technology to support this transformation in two important ways.

First, you can use access to extensive libraries of teaching examples and suggestions to tune your instruction to student needs, experiences, and unique situations. For example, Edgate and ProQuestK-12 provide large repertoires of Web-based teaching resources. (***Editor's note:*** Find these URLs and other information in the Resources section on p. 39.) Using online resources such as these, you can search for activities that are consistent with students' learning needs. For example, consider teaching a geography lesson in a classroom where students have limited and extensive experiences with local conditions such as a central business district. You could also use the Edgate site to design language lessons that are related to student cultural experiences from home, such as recipes from Mexico. You can personalize study by using local information resources (e.g., GIS databases, museum records and images online, property records, census data), as a focus for study in science (investigating pollution issues), literature (reading local stories), and social studies (examining the politics of local decisions). Students can use geographic principles to study data about their own neighborhoods as well as examine other features of interest specifically to them.

Second, you can teach students to organize their knowledge using computer-based tools and software simulations that model forming and expressing alternate conceptions of concepts and strategies. For example, CSILE (Computer-Supported Intentional Learning Environments) offers several projects and many application examples in which the technology is integrated into curricula so that students' thinking is revealed. With sites such as these, you can help students focus on their thinking as well as look for information. As students develop understandings, you guide them to examine their conclusions based on interactions between their peers, their writing, the information they collect, and their prior knowledge. By trying to explain their ideas to other students and interacting with their peers around academic content, students improve their thinking skills and gain new knowledge. In addition, by reviewing students' CSILE entries, you can find evidence of the kinds of help students provide for each others' thinking and communication skills.

Interesting

Interested students challenge their existing knowledge and are more likely to develop conceptual frameworks that integrate prior knowledge and new information into understanding. Lack of interest is generally the number one reason that students give for not learning to mastery. By focusing on students' current beliefs, you increase the probabilities that students will be intrigued and explore their understandings. Technologies can be an effective tool to promote this interested and active exploration.

Technology-based demonstrations and illustrations such as the math and science animations at ExploreLearning, the Day in the Life Series, and MathMagic stimulate discussions in which students' current beliefs are expressed and tested. By creating classroom environments that encourage manipulating and discussing new

ideas, you build opportunities for students to engage their interests and examine the perceptions of others. Although these opportunities can be very rich, it is also important to ensure that students have the skills to interact with each other. Sites such as these usually are open to teacher-led and whole class discussion as well as small and independent group work. Technology enables students to propose an effect and then to test that proposal with a virtual manipulative.

Manipulatives are concrete or symbolic artifacts that students interact with while learning new topics. They are powerful instructional aids because they provide active, hands-on exploration of abstract concepts. Research supports the premise that computer-based manipulatives are often more effective than ones involving physical objects, in part because they can dynamically link multiple representations together.

In addition, because there is a wide range of technology-based materials available on many topics, you can provide opportunities for students to self-select learning activities that are developmentally and topic appropriate as well as capture their personal interests. Thus, rather than a single demonstration of a reaction of chemicals or one perspective on a war battlefield, you can open a broad range of options for students to select those that are most interesting to them.

Real Life

Constructivist teaching incorporates students' communities as the context for learning. Consider the Schools For Thought (SFT) project of the Learning Sciences Institute at Vanderbilt University. In the SFT Jasper Woodbury series, students are presented with computer-based scenarios that involve complex information and sophisticated decisions. You contribute to successful learning by guiding students' inquiry through focused questions and directing students to consider how these principles affect their community-generated questions. As students work through the SFT dilemmas, you can help them recognize the many ways they have used information they learned in math, science, social studies, and literature to address the issues raised.

Understanding grows from studying difficult concepts several times and in different ways.

You can also facilitate depth of understanding by integrating technologies into the fabric of teaching as intellectual tools that students use to study, learn, and communicate with others in their classes as well as others in different locations. Students can respond by using organizing tools, making complex calculations, and employing search engines to mirror the strategies they will use outside of school to seek answers. In this way, real life in school becomes as much a second nature response as real life outside of school. The result should be a much higher potential for transfer in addition to deeper and more meaningful learning.

Social

Constructing meaning comes from interacting with others to explain, defend, discuss, and assess our ideas and challenge, question, and comprehend the ideas of others. Social activities allow students to express and develop their understandings with peers as they pursue projects through conversations that stimulate examining and expanding their understandings.

One increasingly common technology-based strategy is to create online communities of students and adults who collaborate on specific problems. For example, Global Lab and CoVis link students from as many other sites as you choose to monitor, collect, and share scientific data. The Global Lab project was tested in more than 300 schools in 30 countries. These technologies provide opportunities for students to join a large community and analyze data in a very diverse social environment.

As students analyze and share conclusions across different cultures and perspectives, you have the opportunity to help them evaluate the quality and quantity of the evidence on which they build their conceptions. One outcome is that you can demonstrate the effects of cultural and geographical perspectives by discussing the reasons for differences. These technology-based collaborative social classrooms create learning environments in which students can openly express their conclusions, challenge the conclusions of others, and build extensive information resources. Your role is to help students develop standards to judge evidence, lead students as they reflect on and discuss issues, and encourage students to form conceptual frameworks based on social considerations of the ideas they are studying.

Active

The visible learning actions students use to gather and consider information include writing, discussing, and searching. The covert actions that result in monitoring and choosing how to learn are reading, listening, monitoring, reflecting, considering, evaluating, and checking.

Technology-based interactivity can be a tool to facilitate active learning with dialogue between students as well as to evaluate and revise their propositions. WebPals is a collaborative interaction between teacher

education students and middle school students in which they jointly read and discuss their interpretations of novels and review implications for their communities and lives. You would moderate these discussions by posing stimulating questions to your students about the novels they read and also about the observations that their Web pals make. By emphasizing thoughtful interpretation of their questions and observations, you show students that how they think is as important as mastering details.

Time

Time and carefully planned experiences are necessary for broad and deep understanding. Two overarching outcomes from in-depth study are essential. First, understanding is the result of well-organized and widely linked concepts. This allows learners to recall and use their knowledge quickly and appropriately in unfamiliar situations. Second, understanding consists of knowing the important questions and cognitive strategies that characterize the disciplines they are studying.

You can employ technology to increase the efficiency and personalization of the time to learn new ideas as well as to rethink and revise existing ideas. Technologies can facilitate these recursive processes in several ways. Word processors and databases can be used to record thoughts and observations so that students can review them regularly and revise as needed. You can embed this individual review in student self-directed routines guided by metacognitive questions such as: Why are you learning this? What do you already know that relates to this information? How interested are you in learning this? How difficult will it be for you to learn? Are you checking your understanding as you study? How should you correct errors? Are there other ways you can study that may be better? These questions focus students to use their time well and to maximize success by selecting and applying the most effective learning strategies.

Understanding grows from studying difficult concepts several times and in different ways. You can use technologies to foster these recursive learning processes by providing the same information in different formats and for different situations. For example, presenting math from sites such as Global Grocery List and MathMagic provides variety and maintains students' interest.

Technology can help teachers and students use time more efficiently. Students are empowered to control and organize their learning in programs that respond to their specific needs. Some examples of tutoring programs that use time efficiently are Get A Clue, which provides vocabulary development through stories, and HomeworkSpot, which provides homework help through access to subject-specific links. With sites such as these, you can link students to many help and reference sites. For structured practice, students can be directed to use many available drill and practice programs tailored to independent use. These resources offer students multiple presentations of classroom lessons that use time efficiently and promote greater understanding.

Supportive scaffolding shows students that you understand their needs and "walk" with them as they work to meet learning goals.

Feedback

Feedback is essential to the process of acquiring and reflecting on the relation between existing knowledge and new information. The feedback you provide is most effective as a continual stream of performance-based observations from which students can revise their thinking as they work on projects. When teachers successfully integrate feedback authentically into projects to support and guide students, learning becomes a journey that is constantly being adjusted as students individually and collectively pursue solving problems or explaining observed phenomena.

Software such as Logal Simulations in Science and Math and Decisions, Decisions in Social Studies and others in nearly all disciplines offer students the opportunity to plug in data or observations and model the results of their efforts. Technology-based feedback is immediate and focused on the learning at hand. Feedback can be presented in graphs that illustrate the effects of the students' propositions and by indicating if a test question has been answered correctly. Test questions can also be put into databases from which practice questions can be generated for students to test their own knowledge. Computer simulations can give students realistic problems to solve for evaluating their use of their knowledge and understanding.

This kind of feedback lets students know what they have and have not learned; students then have the ability to manage their own learning, use their metacognitive skills, and establish personal goals. You can promote this sense of efficacy when students make data-based judgments about what they know and how well they know it. Your models of how to think about using feedback are an important ingredient in students learning to make the most of the feedback they receive.

Constructing continued on p. 39

Constructing continued from p. 13

Supportive

Instructional support provides the right assistance at the right time for learners. You can support or scaffold learning by doing things such as reducing the complexity of a task, limiting the steps needed to solve a problem, providing cues, identifying critical errors, and demonstrating how tasks can be completed.

This kind of supportive scaffolding shows students that you understand their needs and enables you to "walk" with them as they work to meet learning goals. A key part of this support is to determine when students are ready for a nudge and then to provide the scaffold that will support them as they make progress. As learners develop new concepts, the scaffolds are removed.

When you use technologies such as calculators, spreadsheets, and graphing and modeling programs, you help students as they develop their understandings. In addition, you can use computer programs that serve as mentors to students as they develop their skills and knowledge. Programs with access to experts and tutoring also offer scaffolding for students to question their knowledge and find support for exploring questions with multiple correct answers. For example, the site Smarthinking is designed to increase academic retention and achievement for individual students with interactive mentors and tutors. The Electronic Emissary Project is another site that connects online mentors with K–12 students in collaborative and team projects that are curriculum based.

Conclusion

We have described eight characteristics of effective learning environments consistent with modern constructivist theory. As we see research becoming more interdisciplinary—including not only education but also the physiology of the brain, neurology, psychology, and medicine—the constructivist explanation of how to influence learning and learners appears more and more consistent with the emerging evidence. This research has direct and important implications for what we do in classrooms. Classrooms that are active, interesting, learner centered, focused on real life, and social and provide time to learn, frequent and facilitative feedback, and support both learning to be good learners as well as learning content have consistently been shown to be more effective with all learners.

Creating these environments is a daunting challenge and requires considerable restructuring of classroom routines and teaching practices. Nobody denies the challenge is great, and we do not claim that technologies will make the task easy. But, as we have illustrated, technologies can provide teaching tools that you can genuinely integrate into the instructional fabric of classrooms. In addition, we can teach our students to use technologies to meet their own responsibility to become good learners and also use these technologies as effective tools to teach content. The goal of constructivism—teaching students so they know how and what to learn—is the path to fuller and more relevant understanding of life's important lessons.

You can provide opportunities for students to self-select learning activities that are developmentally and topic appropriate as well as capture their personal interests.

Resources

CoVis: http://www.covis.nwu.edu
CSILE: http://www.ed.gov/pubs/EdReformStudies/EdTech/csile.html
Day in the Life Series: http://www.colonialwilliamsburg.com/History/teaching/Dayseries/ditl_index.cfm
Decisions, Decisions in Social Studies: http://www.scholastic.com/products/tomsnyder.htm
Edgate: http://www.edgate.com
Electronic Emissary Project: http://emissary.wm.edu
ExploreLearning: http://www.explorelearning.com
Get A Clue: http://www.getaclue.com
Global Grocery List: http://landmark-project.com/ggl/
Global Lab: http://globallab.terc.edu
HomeworkSpot: http://homeworkspot.com
Logal Simulations in Science and Math: http://www.riverdeep.com/products/logal
MathMagic: http://mathforum.org/mathmagic/
ProQuestK-12: http://www.proquestk12.com
Schools For Thought: http://peabody.vanderbilt.edu/projects/funded/sft/general/sfthome.html
Smarthinking: http://www.smarthinking.com
WebPals: http://teacherbridge.cs.vt.edu/public/projects/Web+Pals/Home

Thomas M. Sherman is a professor of education in the College of Liberal Arts and Human Sciences at Virginia Tech. He teaches courses in educational psychology, evaluation, and instructional design and has written more than 100 articles for professional publications. Tom works regularly with practicing teachers and students in the areas of learning improvement and teaching strategies. He is also active in civic affairs, serving on local and state committees.

Dr. Barbara Kurshan is the president of Educorp Consulting Corporation. She has a doctorate in education with an emphasis on computer-based applications. She has written numerous articles and texts and has designed software and networks to meet the needs of learners. She works with investment banking firms and venture groups on companies related to educational technology. She serves on the boards of Fablevision, Headsprout, and Medalis, and on the advisory boards of Pixel, WorldSage, and Tegrity.

visit www.iste.org/LL